

p248 Q8

specific heat capacity, c is the energy required to change the temperature of a kg of a substance by 1°C or K.

Iron $c = 450 \text{ J/kg}^\circ\text{C}$

water $c = 4180 \text{ J/kg}^\circ\text{C}$

Hydrogen $c = 13\,000 \text{ J/kg}^\circ\text{C}$



Heat, Q is the change in internal energy

Q8

you have 565g of iron at boiling point of water and you put it into water at 0°C and they both end up at 20°C after a while.

$$Q = mc\Delta T = 0.565 \text{ kg} \cdot 450 \text{ J/kg}^\circ\text{C} (20^\circ\text{C} - 100^\circ\text{C})$$
$$= 0.565 \times 450 \times -80 = -20,340.0$$

-20kJ was the change in internal energy of the metal, 20kJ were gained by the water

b) $Q = mc\Delta T$ $m = ?$

$$20340 \text{ J} = m \cdot 4180 \text{ J/kg}^\circ\text{C} (20^\circ\text{C} - 0)$$

$$m = 20340 / (4180 \times 20) = 0.2433$$

0.24kg of water were needed.

Thermal Equilibrium

If you put two, or more, objects in thermal contact, heat flows from the hot object to the cold object until they reach the same temperature, equilibrium temperature, T_E .

heat lost by object A = heat gained by object B

$$-Q_A = Q_B$$

Don't forget the negative sign.

If there are no changes of state

$$-m_A c_A (T_{Af} - T_{Ai}) = m_B c_B (T_{Bf} - T_{Bi})$$

eventually the two objects will be at the same temperature, T_E

$$-m_A c_A (T_E - T_{Ai}) = m_B c_B (T_E - T_{Bi})$$

eg. You put a 67.5g block of metal from a beaker with boiling water into 150 g of water at 20.0°C in an insulated cup.

a) if the equilibrium temperature is 29.0°C, what is the specific heat capacity of the unknown metal?

$$-m_{ACA}(T_E - T_{Ai}) = m_{BCB}(T_E - T_{Bi})$$

$$-(0.0675\text{kg})c(29^\circ\text{C} - 100^\circ\text{C}) = 0.15\text{kg}(4180\text{J/kg}^\circ\text{C})(29^\circ\text{C} - 20^\circ\text{C})$$

$$c = 0.15 \times 4180 \times 9 / (0.0675 \times 71) = 1177.4648$$

$$1.2 \text{ kJ/kg}^\circ\text{C}$$

a) if the metal was iron, what would be the equilibrium temperature?

$$-m_{ACA}(T_E - T_{Ai}) = m_{BCB}(T_E - T_{Bi})$$

$$-(0.0675)(450)(x - 100) = 0.15 \times 4180(x - 20)$$

$$0.0675 \times 450 = 30.375 \quad 30.375 \times 100 = 3,037.5$$

$$-30.375x + 3037.5 = 0.15 \times 4180 = 627.0x - 12540$$

$$627 + 30.375 = 657.375x = 3037.5 + 12540 = 15577.5$$

$$x = 15577.5 / 657.375 = 23.6965$$

$$x = 24^\circ\text{C}$$

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